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# Alexandria Division

AMERICAN MACHINE & FOUNDRY COMPANY

First Bi-monthly Progress Report

# STUDY AND DESIGN OF MULTIPLE OR STACKED DETECTORS AND A SINGLE FIXED DETECTOR

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# INTRODUCTION

Simultaneous detection of a complete diffraction pattern is an attractive but not easy method. The main emphasis of the effort has been, logically, in the detector area itself, although X-ray optics is intimately tied in with the type of detector selected. The approach has been to evaluate theoretically and experimentally an assortment of detectors, select the one or two more promising ones, and evaluate their performance in an integrated diffractometer system. Readout devices for the detectors selected have been chosen and will be constructed for experimental evaluation.

## REPORT OF PROGRESS

### A. X-Ray Optics

During the initial reporting period an intensive study was conducted of X-ray diffraction camera arrangements. Both non-focussing types (e.g., Debye-Scherrer) and focussing types were considered, along with their many variations. Aside from the more obvious factors which apply specifically to the camera (e.g., X-ray intensity, theoretical resolution, size, and weight), it was necessary to consider also compatibility with various detector schemes. Partly because of the uncertainty about the detector to be used, it was decided that some flexibility remain as to the selection of a camera, and that experimental hardware reflect this decision.

A Norelco X-ray diffraction apparatus, capital equipment at this laboratory, is being used in conjunction with the camera experiments. This instrument is equipped with a goniometer and with several conventional X-ray cameras. For the experiments planned this X-ray machine serves as the basic source.

Although our analysis indicated only marginal acceptability of the Debye-Scherrer, it was judged appropriate for completeness that some experimentation be conducted. The advantages of this camera are that it will give well known and catalogued diffraction patterns over a wide angular range. The disadvantages are that the intensities are low because one has to work with a small and collimated beam of primary

X-rays. Another disadvantage is the problem of sample preparation and loading inasmuch as the camera requires very small amounts of sample material. Measurements with this camera are continuing but, as expected, the results are not encouraging.

Figure 1 illustrates the theoretical basis for the hardware being constructed to test the performance of a focussing camera. In this arrangement three Rowland circles of differing diameter are used. This particular design was arrived at because a small circle severely compresses the small $2\theta$ positions and a large circle requires, for large values of $2\theta$, an unsuitably large apparatus. The sample holder and detector mount are designed with optimum versatility. This hardware is now being fabricated and is expected to be available for experimental use in about ten days.

As a first step line intensities, line resolution, and background will be measured on this simulated set-up by means of a standard scintillation counter scanning over a limited range of 2 angles. When the stacked or multiple detectors become available somewhat later in the program, they will be substituted for the single scintillation counter in the same arrangement. By operating the X-ray tube with a copper target at 25 kilovolts and one milliampere, the data obtained will be directly applicable to the final performance characteristics of the instrument.

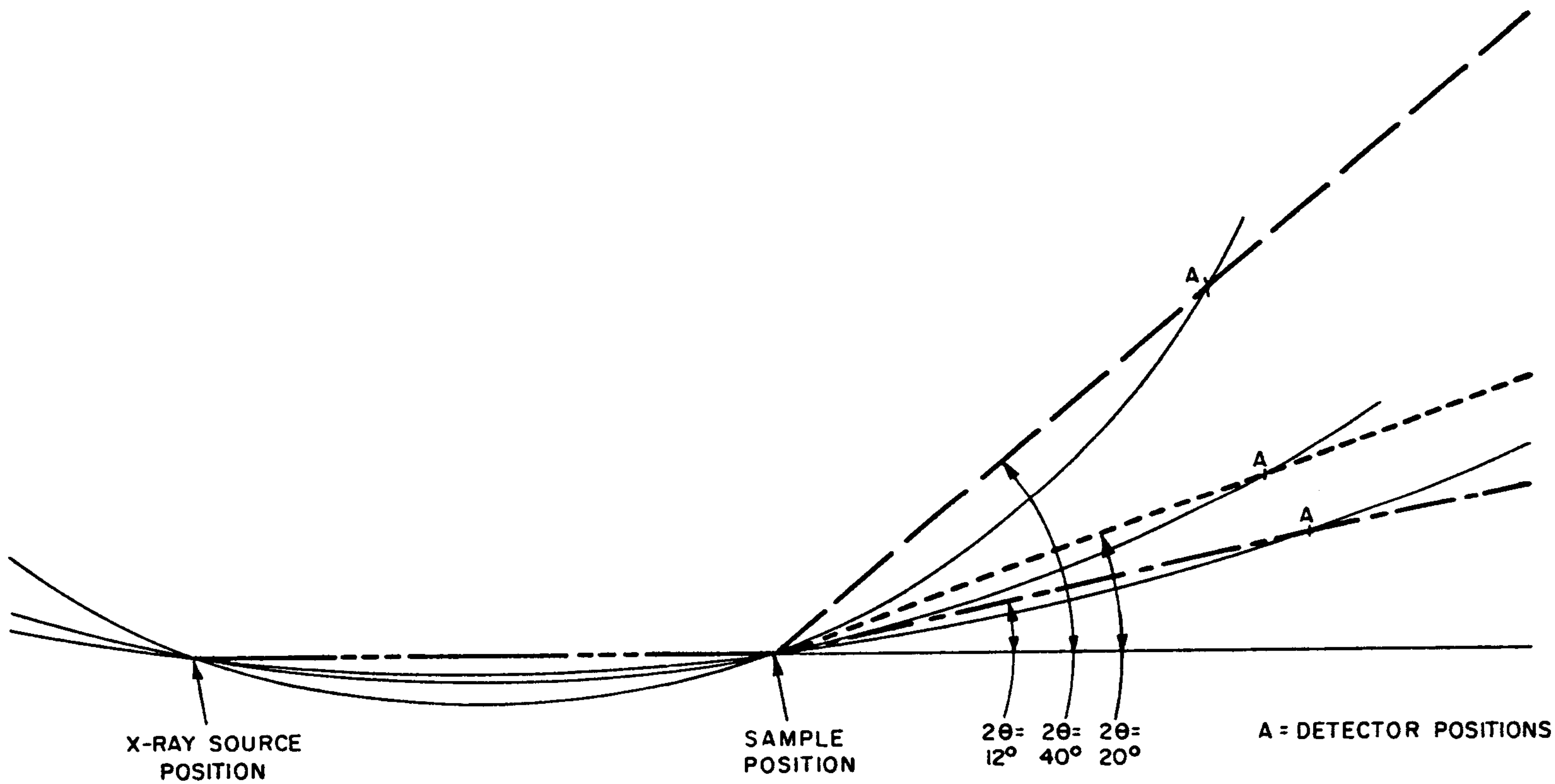


Figure 1. Focussing Geometry Layout

## B. Detectors

The following detectors were considered in this preliminary study phase: Individual stacked geiger counters, multiple geiger counter, scintillation counter, channel-multiplier type counter, and X-ray vidicon. These counters were evaluated on the basis of their spatial resolution, efficiency, sensitivity, as well as the requirements with respect to power supply voltage, complexity of associated electronics, ruggedness, vacuum requirements, price, and temperature characteristics. Findings are summarized in Table 1. The following comments can be made.

Individual stacked geiger counters have a problem of poor resolution. This problem, however, can be circumvented by stacking the counters into multiple rows. In order to achieve the required spatial resolution, a multiple array with about 500 individual counters, each corresponding to the minimum resolvable element, has to be realized. The complexity of such a system makes this approach less attractive than some of the other methods.

The multiple geiger counter, which is similar to the multiple proportional counter shown in Figure 2 of our proposal, has some attractive features. It was decided to use a geiger counter in preference to a proportional counter. The geiger counter does not require a high gain electronic amplifier. Considering that 500 individual channels are required, this will result in a substantial saving of electronics. As

TABLE I

DETECTOR COMPARISONS

| Characteristic | GM Single | GM Multiple | Scintillator | Channel Multiplier | X-Ray Vidicon |
|---|---|---|---|---|---|
| Resolution | Poor | Fair | Poor | Good | Very Good |
| Efficiency | Fair | Fair | High | Poor | Fair |
| Sensitivity | Good | Good | Fair | Fair | Fair |
| Counter Voltage | 400 | 400 | 1000 | 3500 | 500 |
| Readout | Complex | Medium Complex | Complex | Simple | Simple |
| Vacuum | No | No | No | Yes | No |
| Price | High | Medium | Medium | High | Medium |
| Ruggedness | Good | Good | Fair | Good | Good |
| Temperature | Good | Good | Good | Good | $45^{\circ}$C max. |

the estimated dead-time of the geiger counter will be on the order of 50 microseconds, no coincidence losses will occur at the radiation intensity levels to be expected.

The scintillation counter, which is the approach shown in Figure 1-A of our proposal, was studied but its application remains doubtful. The evaluation showed that the problem of optically coupling the scintillator to the fiber optics will result in poor spatial resolution. Furthermore, the extremely low light levels available require the use of a fairly complex image intensifier system. A possible solution to these problems might be the use of a new secondary emission, high sensitivity vidicon presently being developed for the Apollo program for a different application. This device, however, is not available as yet.

The channel-multiplier type counter, which is shown in Figure 1-B of our proposal, was evaluated experimentally. This counter has desirable features except that it does require a somewhat high power supply voltage of 3500 volts. The main unknown, however, with this counter was its efficiency of X-ray detection. This parameter was measured and it was determined that the quantum efficiency is only 2.7 percent. While this value does not rule out the method completely, this and the fact that the counter must be operated in vacuum make it appear disadvantageous.

The X-ray sensitive vidicon is a device equivalent to a regular vidicon except that it will convert X-rays directly into an electrical signal. This results in a detector which is relatively simple and which has excellent resolution.

On the basis of this evaluation, we have decided to proceed with parallel approaches: one using a multiple geiger counter, and the other an X-ray vidicon. The multiple geiger counter, which is based on the principle of a parallel plate geiger counter has been designed and is expected to be available for experimentation in approximately two weeks. For the purpose of this feasibility study we will use an assembly with ten individual channels which is sufficient to measure line intensities and resolution as well as background. Expected efficiency of the counter is 20 percent. The electronic readout circuitry to be used with this counter is described in the next section of this report. Experimental work has been in progress with the X-ray vidicon and we were able to determine its operation and characteristics at wavelengths of 1.5 Angstroms. From the point of view of resolution, simplicity, and reliability, the approach looks very encouraging. Sensitivity, however, is still a major problem which is partly due to the fact that the tube which was evaluated already had been used for a great number of hours. A new tube is being purchased and will be subjected to further testing.

C. Data Handling and Presentation

A data handling and presentation system has been devised. All functions which are expected to be performed in space are fully reproduced in the hardware to be constructed except that only ten channels of primary information will be handled by this feasibility model.

The electronic system concept has been adopted and the basic logic design has been completed. The system concept calls for storing the output of ten channels of a geiger tube and electronically scanning the ten channels plus a sync signal and transmitting this information in serial fashion on a single line. The serial information is then selectively gated into individual channels and fed into a six-digit counter which is to be switched manually between channels. It has been decided, for the feasibility model, to utilize commercially available logic circuitry to the fullest extent possible. This was decided primarily for economic reasons since this is a feasibility study and size, at this point, is not a factor. The feasibility model will be housed in a desk-top 19-inch rack with a logic card rack and master control panel.

Detailed circuitry design has started and parts are being ordered to start construction of the system.

## SUMMARY


Two detectors have been chosen which seem to offer the most advantageous approaches. One of these, the X-ray vidicon, is presently undergoing experimental evaluation to determine its sensitivity. The other, a multi-channel geiger counter, is being constructed. A X-ray focussing camera arrangement has been designed and is being fabricated. Electronic data processing and readout circuitry has been selected for the geiger counter approach. The following program is planned for the next two-month period.

1. Improve performance of X-ray vidicon detector.
2. Evaluate X-ray vidicon with Debye-Scherrer and focussing camera.
3. Evaluate focussing camera for different angular ranges with standard scintillation counter.
4. Test and evaluate multi-channel geiger counter.
5. Test and evaluate electronic readout system.